Experimental design for corotating pinned spiral waves and synchronization

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Abstract. The synchronization phenomena and the mutual coordination is very common in nature. It is widely spread from human brain to menstrual cycle of two friends to network of fireflies. Oscillators in biology do synchronize. Here in this study, we examine the synchronization phenomena in a chemical system with Belousov-Zhabotinsky reaction. We used pinned spiral rotors for our experiments, because Pinning obstacles are considered as scar tissue in our heart. We designed our experiment in such a way where the directions of all the rotors are same. We found a change of synchronization states with time.

Introduction

Self-organization and pattern formation is very ubiquitous in nature. Patterns are seen in animal coats to spiral galaxy. Spiral and scroll waves formation occurs in our brain, heart etc. Formation of spiral waves in our heart is often dangerous and can even lead to death through cardiac arrythmias. So, it is necessary to study the behaviour or the dynamics of the spiral waves for better understanding our cardiac wave patterns.
Study on the control of the dynamics is carried out using various gradients like thermal, electric field or using cross field. Synchronization study in experimental system with BZ reaction is one of the recent kinds of study of these excitable waves. Recent study on interaction of multiple spirals shows the wave-length and core-separation dependency of spirals leads to different kind of interaction like attraction, repulsion. Steinbock and others numerically show the synchronization phenomena of pinned rotors depends on wavelength and the separation of the two rotors. Rotational synchronization in phase and frequency of counterrotating pinned spirals are also shown in simulation as well as in experiments with BZ reaction where the diameters of the obstacles were different. Here in this manuscript, we study the synchronization behaviour of pinned spiral waves moving in same direction. As scar tissue can be compared with the heterogeneous obstacle, so we need to study the dynamics when these spiral waves gets attached to this obstacle.

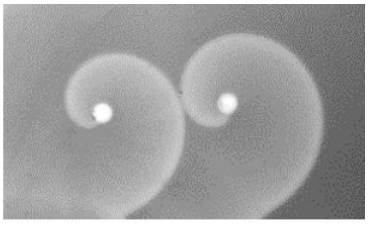

Figure 1: Two corotating pinned spirals.

Results and discussion

We studied about the synchronization phenomena of two corotating spirals pinned to heterogeneity. We carried out our experiments with BZ reaction system, we also did some simulations with Barkley reaction-diffusion model. We observed the synchronization pattern changes with time with compared to beginning.

References

[1]] H. Kalita, P. Khan, and S. Dutta, Rotational synchronization of pinned spiral waves, *Physical Review E* **106**:034201(2022).